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Impact of piglet birthweight and sow parity on mortality rates, growth performance, and carcass traits in pigs

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ABSTRACT - A total of 5502 piglets from 435 sows were selected for evaluation of the effect of piglet birthweight and sow parity on mortality rate (MR), growth performance, and carcass traits in pigs. Piglets were distributed into one of eight categories according to their weight (<600, 601-800, 801-1000, 1001-1200, 1201-1400, 1401-1600, 1601-1800, and >1801 g) and sows were classified according to parity (1-5). The maximum MR during lactation (day 0 to day 21) was found in category <600 g, whereas the lowest was observed in categories ≥1401 g. Pigs with greater body weight (BW) at birth were equivalently greater until 59 days of age. Average daily weight gain (ADG) was improved by increasing piglet birthweight between 0 and 21 days as indicated by a linear regression effect. After weaning, this effect was reduced up to 168 days, indicated by a quadratic, as opposed to linear, regression effect. The increase in growth rates corresponded to improved lean meat content and hot carcass weight. Increasing sow parity corresponded to a quadratic improvement of BW and ADG during lactation, but not after weaning. However, the improved pre-weaning performance was concomitant with a linear increase of within-litter BW and ADG variation. No effect of parity was observed on carcass traits. Piglet birthweight and sow parity influence litter postnatal development, mainly during early life. After weaning, these effects are less evident with a minor impact on carcass traits.

Key Words: carcass quality, growth curve, maternal effect, pig production, swine

Introduction

Despite technological advances in intensive pig production, low body weight (BW) at birth and high within-litter variation are two of the most important factors impairing profitability in the swine production chain. The increased litter size achieved in recent decades has been unfavorably correlated with piglet birthweight and within-litter homogeneity (Knol et al., 2001; Quinton, et al., 2006; Wolf et al., 2008; Kim et al., 2009). These conditions have been shown to have significant effects on piglet subsequent mortality rate (MR), growth performance, carcass, and meat quality traits (Quiniou et al., 2002; Rehfeldt and Kuhn, 2006; Bérard et al., 2010; Fix et al., 2010a). However, considering that most of these studies were performed under stringent experimental conditions in controlled environments, their results may not be suitable for pig husbandry operations that do not meet these conditions. In this sense, it is worth mentioning that pig husbandry operations in Brazil have particular facility designs, such as open walls to dissipate heat during the hot season, allowing moderate room temperature variations throughout the day. Therefore, the use of a Brazilian conventional commercial facility, with non-controlled environmental conditions, as an experimental model would add new insight to this subject.

Among the causes of low birthweight and high within-litter heterogeneity, sow parity is of particular interest. The physiological differences between low- and high-parity sows are known to affect piglet prenatal development (Foxcroft and Town, 2004; Silva et al., 2013). However, the impact of parity on piglet postnatal development, mortality rates, and carcass traits is not well understood. This lack of information limits the development of new strategies to prevent low postnatal growth and to control within-litter variations.

The objectives of this study were to evaluate the effects of piglet birthweight on mortality rate, growth performance, and carcass quality and assess the impact of

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sow parity on piglet birthweight and its variation, as well as on mortality rates, postnatal development, and carcass traits, under commercial conditions.

Material and Methods

Animals were used and cared for in accordance with the Committee on Ethics in Animal Use (CEUA) (case no. 26368.2012.23).

For eleven months, 5502 piglets (Topigs Tybor × Topigs 20) were selected at birth, all born through non-induced deliveries from 435 multiparous sows (Topigs 20; parity 1 to 5) housed in a commercial pig husbandry in Brazil. Five days prior to the predicted delivery day, sows were transferred to suspended maternity pens equipped with plastic flooring for sows and underfloor heating and incandescent lighting for piglets. Only curtains were used to control the room temperature. Average annual temperatures range from 13 to 25 ºC.

For the study of sow parity, a total of 99, 82, 89, 77, and 78 sows of parity 1 to 5 were selected, respectively. For the study of piglet BW at birth, all piglets were identified by placing a tattoo, then individually weighed, and distributed into one out of the following eight weight categories: <600, 601-800, 801-1000, 1001-1200, 1201-1400, 1401-1600, 1601-1800, and >1801 g, with different frequencies in each category. Cross-fostering was performed only after the first 18-h postnatal period, in which sows of similar parity had their litters standardized by size, individual piglet weight, and age. Supplementary colostrum was not used for piglets in any weight category. Traditional handling procedures were performed during lactation and all animals had free access to water and feed. Individual birthweight, gender, mortality rate (MR), average daily weight gain (ADG), body weight at 7 (BW-7), 21 (BW-21), and 59 (BW-59) days of age of the piglets, and sow parity were recorded. Dead animals were also weighed individually to allow correction on ADG values.

At weaning (21±1.56 days of age), piglets were transferred and housed (50 pigs per pen) in nursery barns consisting of 50 pens, which were located at the same pig breeding facility. Pigs were classified visually according to their BW as light-, medium-, or heavy-weight pigs. The nursery pens had suspended plastic flooring, gas heating, nipple drinkers, and an automatic group-feeding system. Feed composition followed the NRC (1998) recommendations. At 60±2.56 days of age, piglets were transported to one of ten different finishers, where they were classified visually according to gender and BW as light-, medium-, or heavy-weight pigs, and were raised until slaughter (168±4.1 days of age). Finishing pens had the capacity to house ten animals and were equipped with nipple drinkers and a manual group-feeding system with 33 cm of length per animal. Pigs were fed four times a day according to a nutritional plan. Only curtains were used to control the room temperature. All finisher farms followed a standardized handling procedure. At 168 days of age, all animals were slaughtered. Feed was withdrawn for a minimum of 16 h prior to transport and all pigs were fasted for a minimum of 4 h at the slaughter plant. After slaughter, hot carcass weight (HCW-168) was recorded and backfat depth (BD) and lean meat content (LMC) were determined using a SKF Ultra Form 300 probe (SKF do Brasil, Cajamar, São Paulo, Brazil) immediately before chilling.

Due to the commercial characteristics of the pig husbandry used in this experiment, some animals were missing during specific periods. The data for these animals were excluded from the statistical analysis for the specific period when they were missing. Mortality rate calculations were based strictly on the number of dead animals; no missing animals were included in this statistics.

Data were analyzed using the SAS (Statistical Analysis System, version 12.1) procedure for mixed models according to a randomized block design with unequal frequencies, with parity or birthweight category as the main independent variables. For the analyses in which birthweight category was the independent variable, parity was considered as a block. The model was: $Y_{ij} = \mu + J_i + e_{ij}$, in which Y_{ij} = dependent variable, μ = general mean, J_i = parity or birthweight category, and e_{ij} = residual error. For the whole experimental period, the individual sow (litter average) was the experimental unit to evaluate parity effects and the individual pig was used as the experimental unit to evaluate birthweight effects. Regression analyses were performed to evaluate the effects of parity and birthweight categories. Data that did not allow parametric analysis were analyzed using the chi-squared test or Fisher's exact test. Differences were considered significant at $P \leq 0.05$ and tendencies at $0.05 < P \leq 0.10$.

Results

Mortality rate in all piglet weight categories during the entire experimental period (0-168 days) was 11.1%. The highest MR was observed during the lactation period (9.7%) and 6.2% of piglets died during the first seven days of life.

The maximum MR at 7 and 21 days was observed in the weight category <600 g, whereas categories ≥1401 g had the lowest MR (Table 1). During the nursery and growing/finishing periods, no differences were found for MR (P>0.05). However, when considering the overall experimental period, MR followed a similar pattern to those observed before weaning, particularly from piglets in weight categories <600 g to 1201-1400 g (Table 1).

Out of the 5502 piglets born alive (Table 1), 17.5% were born weighing ≤1000 g, 60.5% between 1001 and 1600 g, and 22.0% weighed ≥1601 g. The average weights on BW-7, BW-21, and BW-59 were 2.35±0.59, 5.45±1.25, and 20.61±3.86 kg, respectively (Table 2). In all periods (7, 21, and 59 days of age), piglet BW improved with increasing birthweight category, leading to a positive linear effect of birthweight on BW-7 (P<0.01), BW-21 (P<0.05), and BW-59 (P<0.05) (Table 2).

The ADG from 0 to 21, 21 to 59, 59 to 168 days of age, and during the overall experimental period (0-168 days of age) were 0.19±0.06, 0.38±0.09, 0.76±0.08, and 0.49±0.05 g, respectively (Table 3). From 0 to 21 days of age, the ADG improved with increasing piglet birthweight category, leading to a positive linear effect (P<0.01) (Table 3). Additionally, quadratic effects of birthweight were observed on ADG for 21-59 (P<0.01) and 59-168 days (P<0.05), as well as for the whole experimental period (0-168 days of age) (P<0.01; Table 3).

Compared with the heaviest (>1801 g) piglet birthweight categories, ADG for the lightest piglets (<600 g) was lower by 28.8, 30.1, and 10.6% at suckling, post-weaning, and growing/finishing periods, respectively. The overall average HCW-168, BD, and LMC were 82.98±8.94 kg, 14.87±3.78 mm, and 57.6±6.3%, respectively (Table 4). A quadratic effect of birthweight category on HCW-168 (P<0.01) (Table 4) was found, in which heavier piglets at birth were heavier at slaughter. Additionally, among hot carcasses weighing >85 kg, 59.1% were observed in birthweight categories ≥1401 g (P<0.05) and only 23.9% in those weighing ≤1000 g at birth. Although lighter at slaughter, a catch-up growth was observed for the lightest group (birthweight <600 g) compared with the heaviest (birthweight >1801 g). Pigs born weighing <600 g were, on average, 2.54 times lighter at seven days of age and this difference was reduced to 1.72, 1.52, and 1.13 at 21 and 59 days of age and at slaughter, respectively.

Table 1 - Effect of piglet birthweight on mortality rate (MR), total and percentage, from birth to slaughter

Category	Born alive	MR 0-7 days		MR 0-21 days		MR 21-59 days		MR 59-168 days		MR 0-168 days	
	n	n	%	n	%	n	%	n	%	n	%
< 600	82	31	37.8a	41	50.0a	1	2.4	0	0.0	42	51.2a
601-800	266	50	18.8b	76	28.6b	6	3.2	0	0.0	82	30.8b
801-1000	617	60	9.7c	105	17.0c	6	1.2	3	0.6	114	18.5c
1001-1200	982	60	6.1d	87	8.9d	8	0.9	4	0.5	99	10.1d
1201-1400	1259	64	5.1de	102	8.1de	12	1.0	3	0.3	117	9.3de
1401-1600	1086	37	3.4ef	61	5.6ef	14	1.4	4	0.4	79	7.3de
1601-1800	753	25	3.3ef	39	5.2f	6	0.8	2	0.3	47	6.2e
> 1801	457	12	2.6f	21	4.6f	6	1.4	4	0.9	31	6.8de
Total	5502	339	-	532	-	59	-	20	-	611	-

a-f - Differences between means in the column with different letters are significant by the Fisher's exact test (P<0.05).

Table 2 - Effect of piglet birthweight on piglet body weight at 7 (BW-7), 21 (BW-21), and 59 (BW-59) days of age

Category	n 7 days	BW-7 (kg)[1]	n 21 days	BW-21 (kg)[2]	n 59 days	BW-59 (kg)[3]
< 600	39	1.20h	36	3.73g	35	15.24g
601-800	199	1.49g	177	4.17g	164	16.62g
801-1000	524	1.78f	491	4.69f	463	18.48f
1001-1200	891	2.06e	854	5.07e	823	19.52e
1201-1400	1167	2.31d	1115	5.35d	1067	20.54d
1401-1600	1029	2.55c	988	5.76c	946	21.37c
1601-1800	708	2.78b	680	6.05b	669	22.20b
> 1801	436	3.05a	407	6.41a	405	23.09a
SEM	-	0.59	-	1.25	-	3.86
P-value	-	<0.01	-	<0.05	-	<0.05

SEM - standard error of the mean.
[1] Within a column, there is a linear effect as birthweight increases ($y = 0.652431 + 0.00126385\ x$; $R^2 = 1.00$; P<0.01).
[2] Within a column, there is a linear effect as birthweight increases ($y = 3.07264 + 0.00176795\ x$; $R^2 = 0.99$; P<0.05).
[3] Within a column, there is a linear effect as birthweight increases ($y = 14.0181 + 0.0048847\ x$, $R^2 = 0.98$; P<0.05).
a-h - Differences between means in the column with different letters are significant (P<0.01; P<0.05).

No difference for BD was observed (14.87±3.78 mm; P = 0.24) among birthweight categories, whereas a positive linear effect of birthweight category was found on LMC (P<0.01) (Table 4).

No effect of sow parity on MR was observed during any of the studied periods. Average values were 6.2% for 0-7 days, 9.7% for 0-21 days, 1.2% for 21-59 days, 0.4% for 59-168 days, and 11.1% for 0-168 days of age. The overall average number of piglets born alive was 12.72±3.26 and a positive linear effect of parity was observed (P<0.01) (Table 5).

Piglet average weight at birth, BW-7, BW-21, and BW-59 were 1.36±0.21, 2.37±0.36, 5.46±0.69, and 20.68±2.23, respectively. No regression effect was observed on birthweight despite the significant effect of parity (P<0.05). However, a quadratic effect of parity on BW-7 (P<0.01), BW-21 (P<0.01), and BW-59 (P = 0.06) (Table 5) was observed. Piglet average BW variation (BW- CV) at birth (BW-0 CV), 7, 21, and 59 days of age were 20.4±6.3, 20.5±6.7, 19.7±5.5, and 16.1±5.5%, respectively (Table 5). Positive linear effects of parity on BW-0 CV (P<0.01), BW-7 CV (P<0.01), and BW-21 CV (P<0.01) (Table 5) were observed, but not for BW-59 CV (P = 1.00).

The ADG from 0 to 21, 21 to 59, and 59 to 168 days of age and during the overall experimental period (0-168 days) were 0.12±0.03, 0.40±0.05, 0.77±0.05, and 0.49±0.03 g, respectively (Table 6). From 0 to 21 days of age, parity had a quadratic effect on ADG (P<0.05) (Table 6), but no effect was observed from 21 to 59 days of age (P = 0.18). During the growing-finishing phase (59-168 days of age) and considering the whole experimental period (0-168 days of age), no regression effect was found, despite a significant effect of parity on ADG (P<0.05). Average ADG variation (ADG-CV) from 0-21, 21-59, 59-168 days of age, and during the overall experimental period (0-168 days) were 30.5±8.5%, 19.1±7.6%, 8.9±3.7%, and 9.1±3.6%, respectively (Table 6). Parity had a positive linear effect on ADG-CV from 0 to 21 days of age (P<0.05) (Table 6), but not for any other periods (P≥0.18).

The overall average HCW-168, BD, and LMC were 84.01±5.58 kg, 14.92±2.04 mm, and 57.8±3.1%,

Table 3 - Effect of piglet birthweight on average daily gain (ADG) from birth to slaughter

Category	0-21 days		21-59 days		59-168 days		0-168 days	
	n	ADG (kg)[1]	n	ADG (kg)[2]	n	ADG (kg)[3]	n	ADG (kg)[4]
< 600	36	0.15d	33	0.31e	19	0.71f	21	0.461e
601-800	177	0.17d	158	0.32e	111	0.70def	121	0.46cde
801-1000	491	0.18c	449	0.36d	289	0.73e	317	0.47d
1001-1200	854	0.19bc	795	0.38c	517	0.75d	564	0.49c
1201-1400	1115	0.19b	1037	0.40b	649	0.77c	708	0.50b
1401-1600	988	0.20a	921	0.41b	589	0.78b	634	0.50ab
1601-1800	680	0.21a	641	0.42a	415	0.79ab	444	0.51a
> 1801	407	0.21a	385	0.44a	234	0.80a	251	0.51a
SEM	-	0.06	-	0.09	-	0.08	-	0.05

SEM - standard error of the mean.
[1] Within a column, there is a linear effect as birthweight increases ($y = 0.143752 + 0.0000376777x$; R = 0.97; $P<0.01$).
[2] Within a column, there is a quadratic effect as birthweight increases ($y = 0.226473 + 0.000180388x - 0.000000037078x^2$; $R^2 = 0.99$; $P<0.01$).
[3] Within a column, there is a quadratic effect as birthweight increases ($y = 0.615628 + 0.000160014x - 0.0000000330603x^2$; $R^2 = 0.98$; $P<0.05$).
[4] Within a column, there is a quadratic effect as birthweight increases ($y = 0.402945 + 0.0000979284x - 0.0000000212952x^2$; $R^2 = 0.99$; $P<0.01$).
a-f - Differences between means in the column with different letters are significant.

Table 4 - Effect of piglet birthweight on hot carcass weight at 168 days of age (HCW-168), carcasses heavier than 85 kg at slaughter, backfat depth (BD), and lean meat content (LMC)

Category	n 168 days	HCW-168 (kg)[1]	Carcass > 85 kg (%)[2]	BD (mm)	LMC (%)[3]
< 600	21	78.01def	23.8d	14.24	55.9abc
601-800	121	77.63f	19.0d	15.54	56.3c
801-1000	317	80.50e	28.4d	14.52	57.7abc
1001-1200	564	82.53d	37.8c	14.94	57.9abc
1201-1400	708	84.45c	48.3b	15.02	57.6bc
1401-1600	634	85.74bc	55.8a	15.06	58.4ab
1601-1800	444	87.19ab	60.1a	14.87	58.7a
> 1801	251	87.82a	61.4a	14.78	58.3abc
SEM		8.94	-	3.78	6.3
P-value	-	<0.01	<0.05	0.24	<0.01

SEM - standard error of the mean.
[1] Within a column, there is a quadratic effect as birthweight increases ($y = 67.8432 + 0.0172351x - 0.00000349537x^2$; $R^2 = 0.99$; $P<0.01$).
[2] a-d - Differences between means in the column with different letters are significant by the chi-squared test ($P<0.05$).
[3] Within a column, there is a linear effect as birthweight increases ($y = 56.18 + 0.00134315x$; R = 0.61; $P<0.01$).

respectively (Table 7). Although the effect of parity on HCW-168 was significant (P<0.05), no regression effect was found. Similar to the results for BW-59, a relatively narrow range of weights was observed at slaughter (82.33±5.58 to 84.94±5.58 kg). Analyzing this data (Table 7) from another standpoint (% carcass >85 kg), parity 2 had the heaviest carcasses whereas parity 1 and 4 had the lowest percentage of heavy carcasses (P<0.05).

No regression effect was observed for LMC, despite a significant effect of parity (P<0.01). For BD, a quadratic effect of parity was found ($y = 13.7468 + 0.913812\ x - 0.142904\ x^2$; $R^2 = 0.78$; P = 0.06). Variation of HCW, BD (BD-CV), and LMC (LMC-CV) were 8.9±3.6, 22.3±8.6, and 10.4±4.2%, respectively (Table 7). No effect of parity was found on HCW-168 CV (P = 0.26), BD-CV (P = 0.12), and LMC-CV (P = 0.10).

Table 5 - Effect of sow parity on the number of piglets born alive, piglet BW and BW variation at birth (BW-0 CV), 7 (BW-7 CV), 21 (BW-21 CV), and 59 (BW-59 CV) days of age

Parity	Born alive[1]	0 day		7 days		21 days		59 days	
		BW (kg)	CV (%)[2]	BW (kg)[3]	CV (%)[4]	BW (kg)[5]	CV (%)[6]	BW (kg)[7]	CV (%)
1	11.9	1.33	17.1c	2.31	16.9b	5.16	16.9	20.25	16.4
2	11.6	1.42	19.7b	2.51	18.5b	5.57	19.2	21.07	15.8
3	13.3	1.35	21.2ab	2.36	22.0a	5.53	20.3	21.00	15.5
4	13.4	1.33	21.5ab	2.36	21.8a	5.58	20.2	20.42	16.1
5	13.4	1.36	22.5a	2.31	23.3a	5.48	21.7	20.67	16.8
SEM	3.26	0.21	6.3	0.36	6.7	0.69	6.5	2.23	5.5
P-value	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	0.06	1.00

BW - body weight; CV - coefficient of variation; SEM - standard error of the mean.
[1] Within a column, there is a linear effect as parity increases ($y = 11.3343 + 0.466546\ x$; $R^2 = 0.71$; P<0.01).
[2] Within a column, there is a linear effect as parity increases ($y = 16.4614 + 1.30835\ x$; $R^2 = 0.90$; P<0.01).
[3] Within a column, there is a quadratic effect as parity increases ($y = 2.22465 + 0.144355\ x - 0.0262341\ x^2$; $R^2 = 0.40$; P<0.01).
[4] Within a column, there is a linear effect as parity increases ($y = 15.6387 + 1.62569\ x$; $R^2 = 0.90$; P<0.01).
[5] Within a column, there is a quadratic effect as parity increases ($y = 4.79374 + 0.467216\ x - 0.0667481\ x^2$; $R^2 = 0.87$; P<0.01).
[6] Within a column, there is a linear effect as parity increases ($y = 16.3629 + 1.09681\ x$; $R^2 = 0.89$; P<0.01).
[7] Within a column, there is a quadratic effect as parity increases ($y = 19.7227 + 0.782882\ x - 0.126494\ x^2$; $R^2 = 0.45$; P = 0.06).
a,b,c - Differences between means in the column with different letters are significant (P<0.01).

Table 6 - Effect of sow parity on average daily gain (ADG) and ADG variation (ADG-CV) from birth to slaughter

Parity	0-21 days		21-59 days		59-168 days		0-168 days	
	ADG (kg)[1]	CV (%)[2]	ADG (kg)	CV (%)	ADG (kg)	CV (%)	ADG (kg)	CV (%)
1	0.18	21.9	0.40	19.6	0.77	8.9	0.49	8.9
2	0.20	53.6	0.41	19.1	0.77	9.0	0.49	9.2
3	0.20	25.2	0.41	18.0	0.78	8.7	0.50	9.0
4	0.20	24.6	0.39	19.3	0.75	9.6	0.48	9.8
5	0.19	27.0	0.40	19.6	0.77	8.3	0.49	8.4
SEM	0.03	8.5	0.05	7.6	0.05	3.7	0.03	3.6
P-value	<0.05	<0.05	0.18	1.00	<0.05	0.25	<0.05	0.23

CV - coefficient of variation; SEM - standard error of the mean.
[1] Within a column, there is a quadratic effect as parity increases ($y = 0.164680 + 0.0205789\ x - 0.00289833\ x^2$; $R^2 = 0.94$; P<0.05).
[2] Within a column, there is a linear effect as parity increases ($y = 21.0420 + 1.13989\ x$; $R^2 = 0.88$; P<0.05).

Table 7 - Effect of sow parity on hot carcass weight (HCW-168) and variation (HCW-168 CV) at 168 days of age, carcasses heavier than 85 kg, backfat depth (BD) and variation (BD-CV), and lean meat content (LMC) and variation (LMC-CV)

Parity	HCW-168 (kg)	HCW-168 CV (%)	Carcass > 85 kg (%)[1]	BD (mm)[2]	BD-CV (%)	LMC (%)	LMC-CV (%)
1	84.09	8.8	49.9bc	14.44	20.5	58.3	9.8
2	84.41	9.1	50.5c	15.26	24.0	57.2	10.7
3	84.94	9.0	47.2b	15.04	22.1	58.3	10.2
4	82.33	9.6	40.0a	15.10	23.0	57.1	11.4
5	84.27	8.4	48.3b	14.78	22.0	58.3	9.9
SEM	5.58	3.6	-	2.04	8.6	3.1	4.2
P-value	<0.05	0.26	<0.05	0.06	0.12	<0.01	0.10

CV - coefficient of variation; SEM - standard error of the mean.
[1] a,b,c - Differences between means in the column with different letters are significant by the chi-squared test (P<0.05).
[2] Within a column, there is a quadratic effect as parity increases ($y = 13.7468 + 0.913812\ x - 0.142904\ x^2$; $R^2 = 0.78$; P = 0.06).

Discussion

Concerning MR, our results (Table 1) are in agreement with other studies (Gardner et al., 1989; Quiniou et al., 2002) that reported the lowest survival rates from birth to weaning in piglets weighing <1 kg at birth. These authors also reported increased odds of survival from birth to weaning with increasing birthweight. Among the factors affecting MR up to slaughter age, neonatal mortality is the most important (Cronin et al., 2000; Marchant et al., 2000; Quiniou et al., 2002). According to Fix et al. (2010b), the main causes of death during early lactation are related to low vitality and energy intake due to insufficient colostrum intake, especially by light-birthweight piglets (Le Dividich et al., 2005; Devillers et al., 2007). These factors may have been the major contributors to the present MR because starvation was the main cause of death for up to 7 and 21 days of age (59.8 and 55.6%, respectively; data not shown) among piglet categories ≤1000 g at birth.

The results of performance obtained (Tables 2 and 3) are consistent with previous studies (Powell and Aberle, 1980; Quiniou et al., 2002; Smith et al., 2007) in which lighter piglets at birth or at weaning remained lighter until slaughter. It has been known for many years that light-birthweight piglets differ biologically from their heavier littermates. Among these differences, the smaller number of secondary muscle fibers (Wigmore and Stickland, 1983) and impaired intestinal development (Alvarenga et al., 2013) are likely to interfere with long-term growth.

Although birthweight category had a marked influence on BW of pigs in all periods, these effects on ADG decreased over time. The lower ADG during the lactation period observed in this study may be explained by light-birthweight piglets that consume less milk per suckle than their heavier littermates (Le Dividich, 1999). However, during later periods, differences in growth performance among piglets in the various birthweight categories do not appear to be related to difference in food intake. In fact, to prevent possible interference of pig BW variation on feed intake (e.g., disputes for feeder space), during nursery and growing/finishing periods, pigs were selected and housed according to their BW. Moreover, feed allowance was pre-determined by a nutritional plan and optimized by the feeder length, allowing all animals in a pen concomitant access to the feeder. Therefore, although feed was not provided *ad libitum* in this study, it is unlikely that light piglets had impaired feed intake compared with heavy piglets. Considering the intestinal morphological disturbance experienced by light-birthweight pigs, due to impairments of gene expression related to growth (Alvarenga et al., 2013), which is negatively correlated to piglet postnatal growth performance, it is reasonable to argue that physiological immaturity may have reduced intestinal digestive capacities, affecting the ADG of piglets.

In relation to the carcass results (Table 4), according to Alvarenga et al. (2013), under Brazilian commercial conditions, high-birthweight piglets (1800-2200 g) have better carcass yield than piglets weighing 800-1200 g at birth; however, Beaulieu et al. (2010) in Canada, did not find any differences for carcass quality between light- and heavy-birthweight piglets. In the present study, performed under Brazilian commercial conditions and comprising a large range of birthweight categories, piglet birthweight had a direct effect on LMC, but not on BD. It is noteworthy that data regarding the impact of birthweight category on carcass traits are inconsistent (Gondret et al., 2005, 2006), likely due to differences in feeding strategies, rearing conditions, and the range of piglet birthweight used between studies.

Considering de effect of sow parity on ADG and ADG-CV (Table 6), similarly, looking at this factor on birthweight, parity affected these parameters particularly during the lactation period. The higher volume of milk produced by older sows (Beyer et al., 2007) may explain the higher ADG in these categories during the lactation period. After weaning, however, environmental factors appear to prevail and account for the differences in ADG and ADG-CV observed in the present study. Nevertheless, it cannot be ruled out that factors related to parity, such as the ones affecting gastrointestinal morphology (Alvarenga et al., 2013) and muscle fiber development (Silva et al., 2013), may not impair the postnatal performance of piglets.

Concerning the effects of sow parity on carcass parameters (Table 7), our results are consistent with those of Tang et al. (2008) for the effects of parity on BD and strengthen the known effect of BD of sows on litter BD at slaughter (Amdi et al., 2014).

Conclusions

Both piglet birthweight and sow parity affect piglet post-natal development, mainly during early life. Piglets can partially counteract the impairments of light birthweight on growth performance during the postnatal period.

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